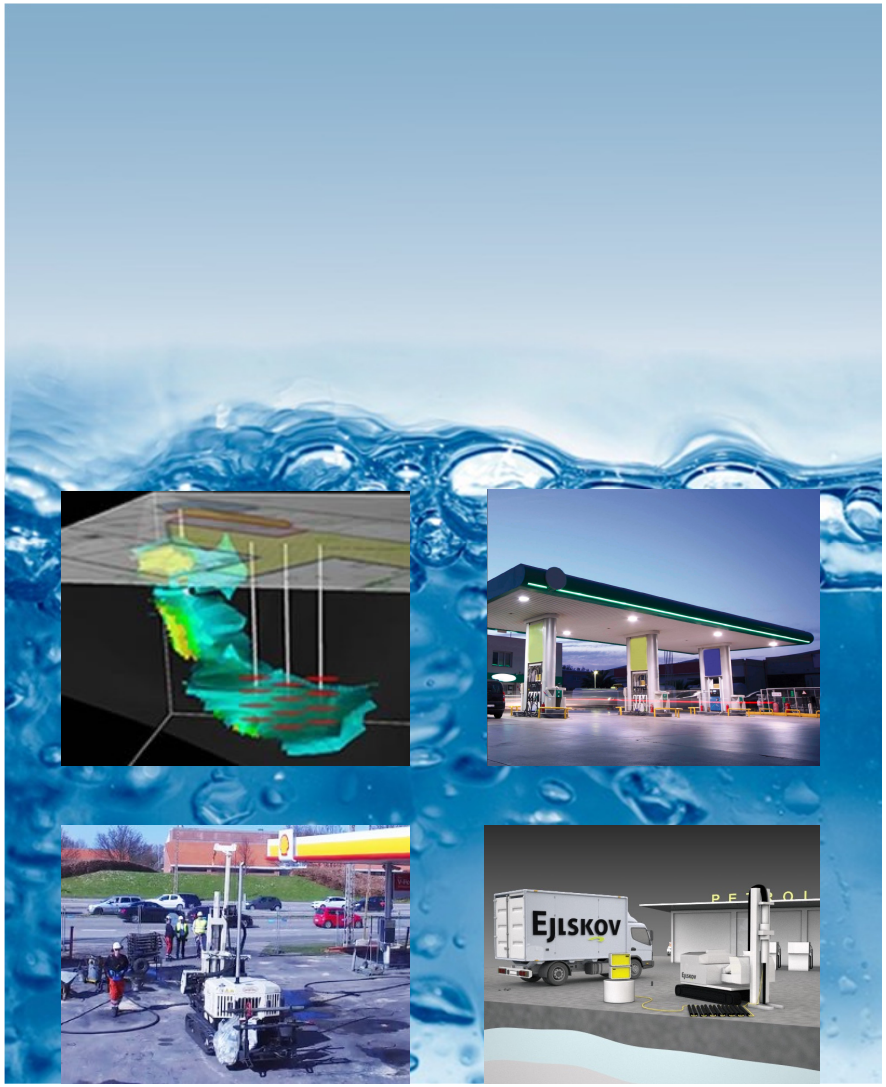

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Remedial Site Characterization using MIP and high resolution soil sampling

Gabriele Giorgio Ceriani

Environmantal Engineer / Remediation Specialist



Ejlskov A/S

- Founded in 1999 by Palle Ejlskov
- Based in Aarhus (Jutland – Denmark)
- Main business activities focused on high detailed site characterization and injection based in-situ remediation
- Currently 23 employees (Geologists, Engineers, Software developer, Field Technicians)
- Ejlskov is specialized in:
  - Soil and groundwater investigations
  - Contamination Risk evaluation towards groundwater, indoor climate and physical contact
  - Insitu Site Remediation (Trap & Treat® and other technologies)
  - Turn Key solitions to soil and groundwater contamination problems
  - Environmental risk towards groundwater, indoor climate and physical contact
  - Consulting services to local developers and authorities
  - Environmental Due Diligence and EHS Audits

Presentation Layout / Agenda

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PART ONE

- Geoprobe System
  - Introduction to the method
  - Direct Sensing
    - Membrane Interface Probing (MIP)
  - Soil Coring – Dual Tube
  - Well installation/Groundwater sampling
- Remedial Site Characterization
  - Preliminary planning
  - Delineation using MIP
  - High resolution soil sampling
- 2D/3D modelling
  - 2D modeling as planning tool (Dynamic modelling)
  - Data evaluation and 3D Modeling (Final model)

PART TWO

- Case Studies
  1. Active Retail Station, Kvistgaard (Denmark)
  2. Active Retail Station, Copenhagen (Denmark)
  3. Dry Cleaning Facility (Finland)
- Conclusions and Lessons Learned
- Insitu Site Remediation -Trap & Treat® concept
  - BOS100®/CAT100 ® for chlorinated solvents,
  - BOS200® for Hydrocarbons, BTEX and MTBE,
  - Injection method/Installation,
  - Economical perspectives and benefits?

Geoprobe System

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- Introduction to the Geoprobe system
- Ejlskov Rigs
- Direct Sensing (MIP, EC)
- Soil Coring (Soil sampling)
- Well installation (Ground water sampling)

Geoprobe System

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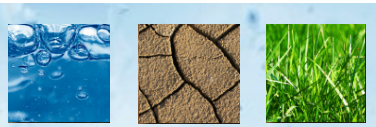
Key Features:

- Based on Direct Push Technology
  - Steel rods (1,25” – 3,25”)
  - Auger drillings if requested (Solid-/Hollow Stem Augers)
- Penetration depth in non-consolidated sediments – 25-35 m.
  - Cannot pennetrate consoildated rock types, Bedrock, Limestone etc.
- Mobile and flexible rigs
  - Various sizes: 0,5-4,5 tons
  - Catepillar Tracks
  - Various tools (Direct Sensing, Well installation, Level specific Soil- and groundwater sampling, slug test)



Ejlskov Geoprobe Rigs

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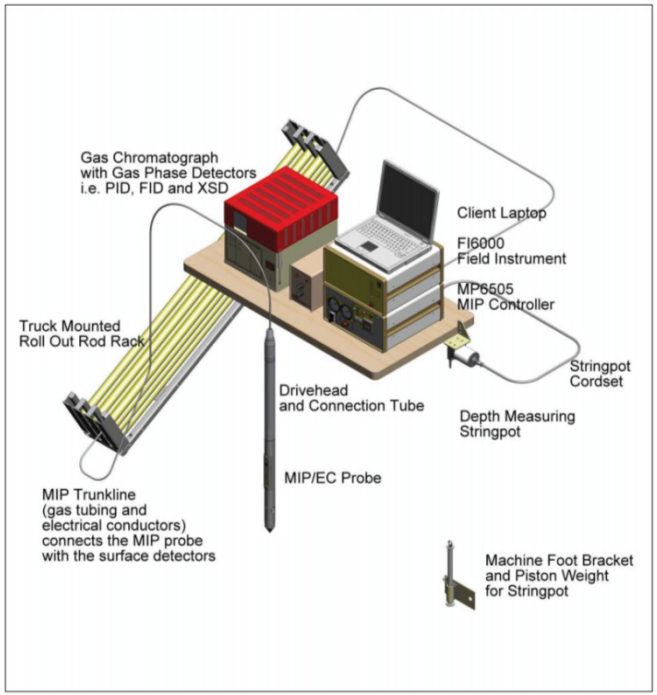
7730DT

7822DT

54DT

540MT

Membrane Interface Probing (MIP) – System set-up



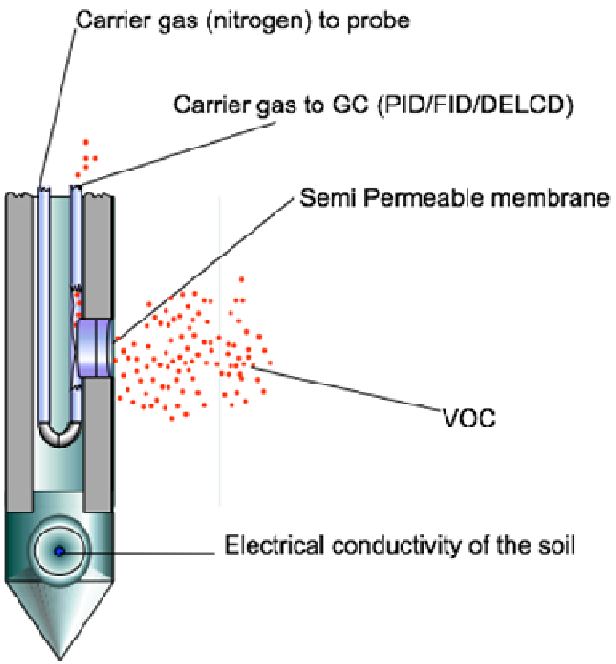
The MIP has been used extensively for mapping the extent of VOC contamination in the subsurface (vertical and horizontal).

The Membrane Interface Probe (MIP) is a screening tool with semi-quantitative capabilities As a logging tool, the MIP offers many benefits to site investigators:

- Useful for detecting and logging both chlorinated and non-chlorinated VOC contaminants.
- Works in both saturated and unsaturated soils.
- Standard tool configurations combine the MIP with at di-pol for lithology logging (Electrical Conductivity).
- Real time contaminant screening information is generated, allowing field adjustment of the site investigation. (Dynamic investigation approach)
- Relative contaminant concentration levels (signal output in µV)



Membrane Interface Probing (MIP) - Probe



- The MIP membrane is semi-permeable and is comprised of a thin film polymer impregnated into a stainless steel screen for support.
- The membrane is approximately 6.35mm in diameter. The membrane is placed in a heated block attached to the probe.
- This block is heated to approximately 90-120 ℃ as the probe is advanced into the soil. - Heating the Probe accelerates membrane diffusion while at the same time minimizing membrane absorption.
- Diffusion across the membrane is driven by the concentration gradient between the contaminated soil and the clean carrier gas behind the membrane.
- A constant gas flow of 35-45 mL/min sweeps behind the membrane and carries the contaminants to the gas phase detectors at the surface (FID,PID and XSD).
- Travel time from the membrane interface to the detector(s) is approx. 30-45sec (depending on the length of trunkline and flow rate).

Membrane Interface Probing (MIP) - Detectors

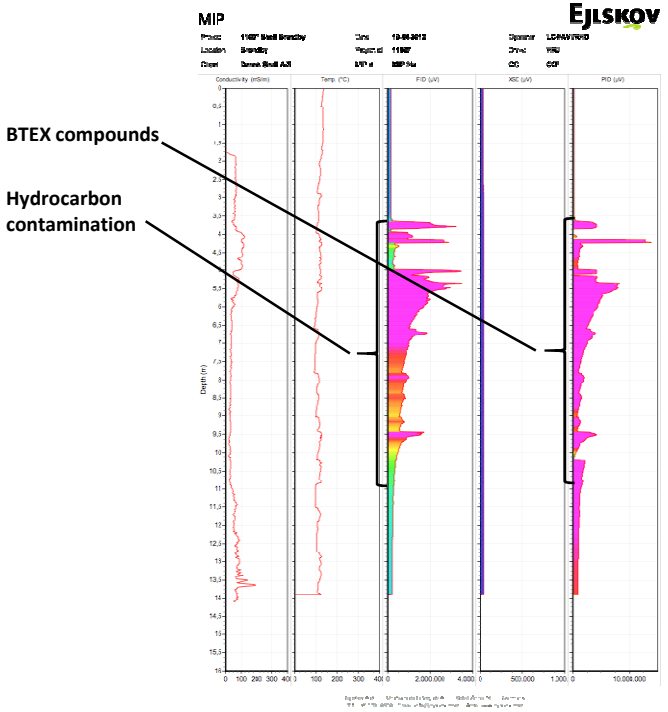
- **PID (Photo Ionization Detector)**
  Aromatic compounds like BTEX and PCE, TCE, DCE, VC……
- **FID (Flame Ionization Detector)**
  Alkanes inkl. Methane
- **XSD (Halogen Specific Detector)**
  Halogenated compounds - Cl^-, Br^-, Fl^-

- The MIP system is checked before each MIP according to the Geoprobe Standard Procedure.

- **Detection Limits**

Detector	Detection Limit*
PID	0,2-2 ppm
FID	1-20 ppm
XSD	0,1-2 ppm

** http://geoprobe.com/mip-specifications*



Soil Coring – Geoprobe Dual Tube

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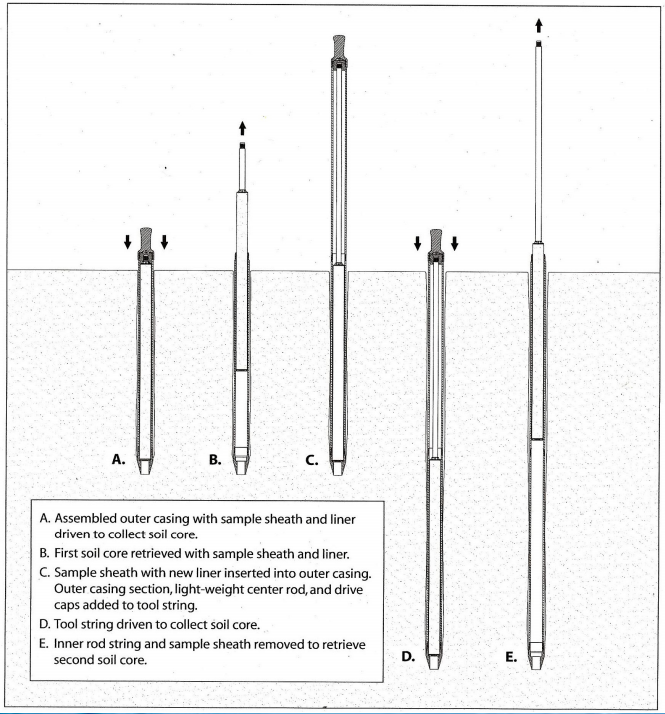
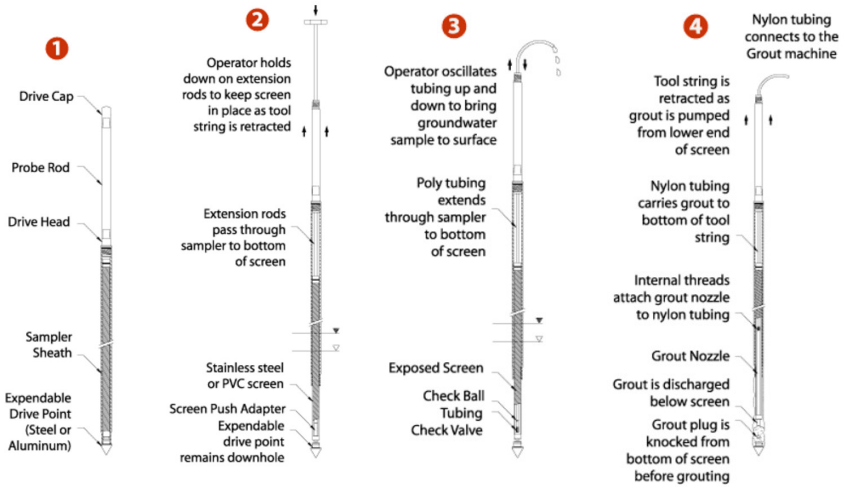
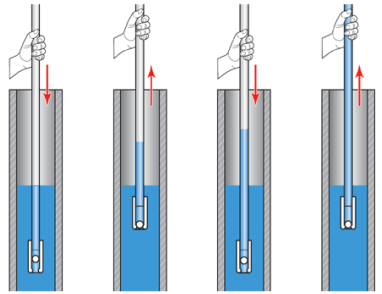


- The Dual Tube method for continuous soil coring,
- Sampling of all unconsolidated soil types,
- Soil Core deliveres in transparent PVC Liners (1,2 m length),
- Core Diameter: DT21 – 38 mm dia. / DT32 – 47 mm dia.
- Soil sampling from discrete sampling depth

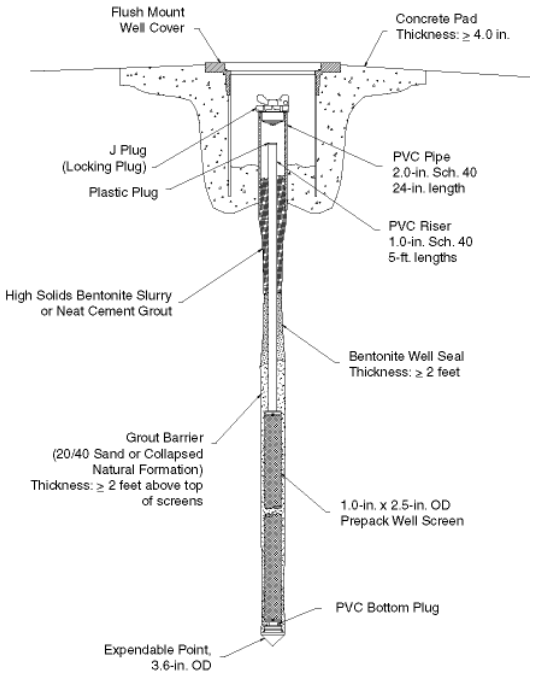
Well Installation – Geoprobe SP16



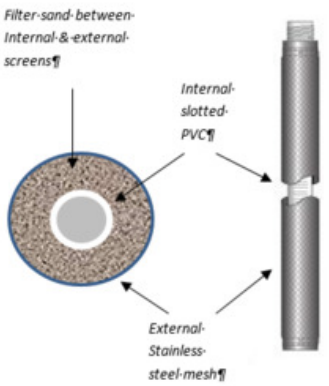
- Geoprobe Screen Point Sampler (SP16),
- Stainless steel screens (25 mm OD) – 1 meter screen length,
- Temporary well installation for descrete groundwater sampling,
- Sampling with Peristaltic pump or Inertia Pump



Well Installation – Permanent Monitoring Well



- Geoprobe Prepacked PVC screens (12,5 – 50 mm OD) (or regular standard PEHD screens <63 mm OD),
- Direct Push Installation – No handling of contaminated soil traditional auger methods,
- Prepacked screen length: 0,9-1,5 meter
  Standard PEHD screen length: 0,5-2 meters
  (Screens can be connected for extended screen interval),
- Prepacked screens ensures optimal installation of filter pack,
- Sampling with Peristaltic pump or Submersible pumps depending on internal well diameter and groundwater level.



Remedial Design Characterization

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- Preliminary planning
- Site investigation/delineation using MIP and 2D-modelling
- High resolution soil sampling
- Monitoring Well installation and groundwater water sampling

Remedial Design Characterization (RDC)

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Initial Site Evaluation based on available data:

- Review of Existing Soil and Groundwater Data
- Well and Borehole Logs
- Saturated and Unsaturated Soil Data
- Groundwater Data – Vertical Profile
- Potentiometric Data
- Previous/On-going Remedial Efforts?
- Physical Site Constraints – Tank Pits, Utilities…etc.,
- Critical Receptors (Groundwater Abstraction Wells, Streams etc.)
- Develop a preliminary Site Model

Dynamic Site Characterisation

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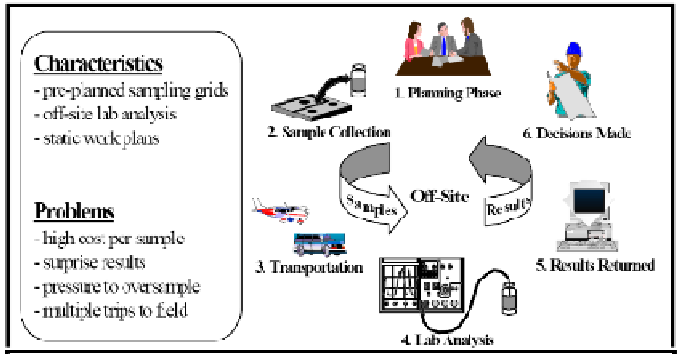
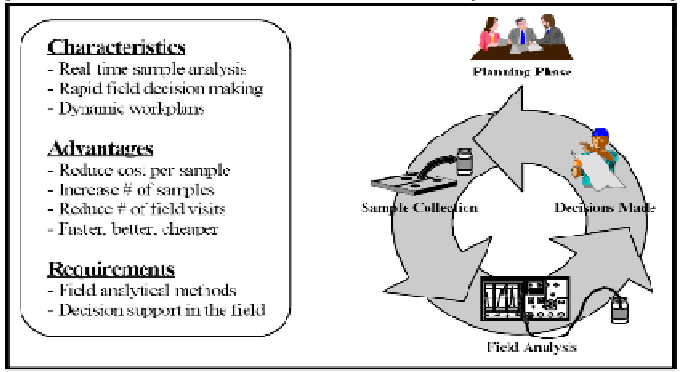
Traditional



Dynamic



Dynamic field investigation with high resolution =>

Less cost per data point

Site Investigation

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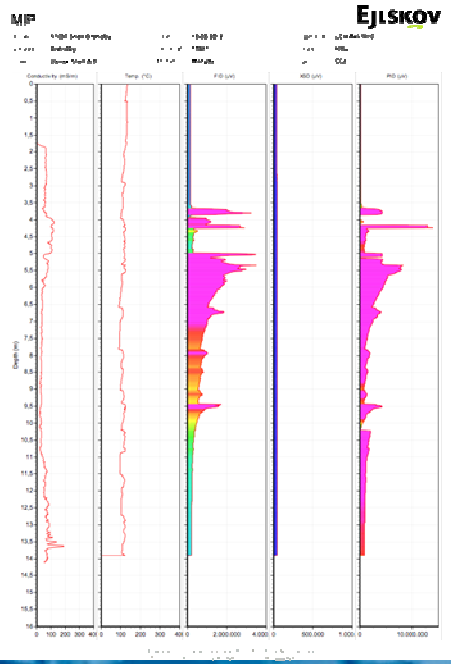

HOW

- Membrane Interphase Probe
- Assess real time data and modify RDC strategy
- Collect relevant / high frequency soil samples
- Conduct Screen Point Sampling / Install Cluster Wells

Strategy

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- Delineate and describe the contamination qualitatively with MIP
- Adapt the strategy continuously depending on real time results
- Collect relevant samples (soil gas, soil or groundwater) for the mass model
- Perform the appropriate field tests (slugtest, field analyzes)
- Go home with all data needed for further decisions



Remedial Design Characterisation

Membran Interface Probe - MIP

High Resolution sampling

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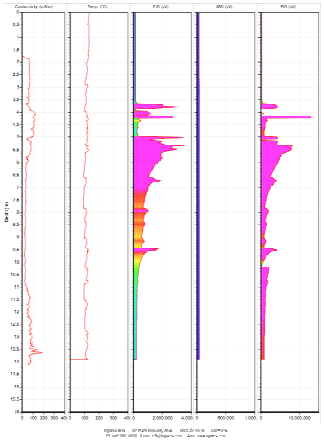

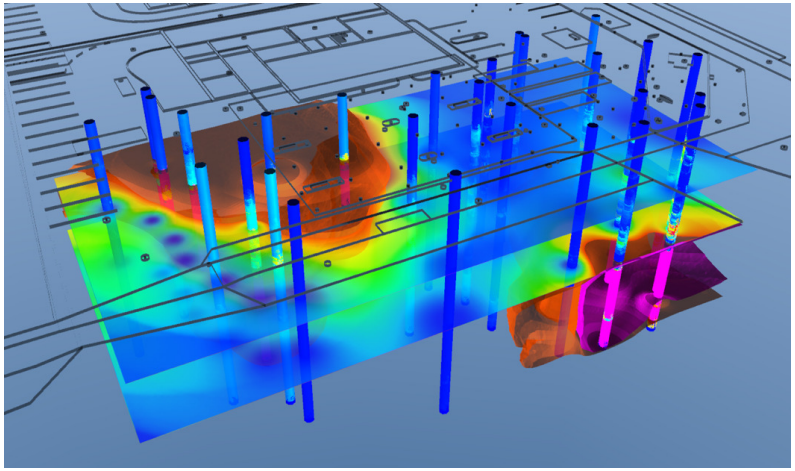

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Ongoing 2D/3D Modeling and data evaluation

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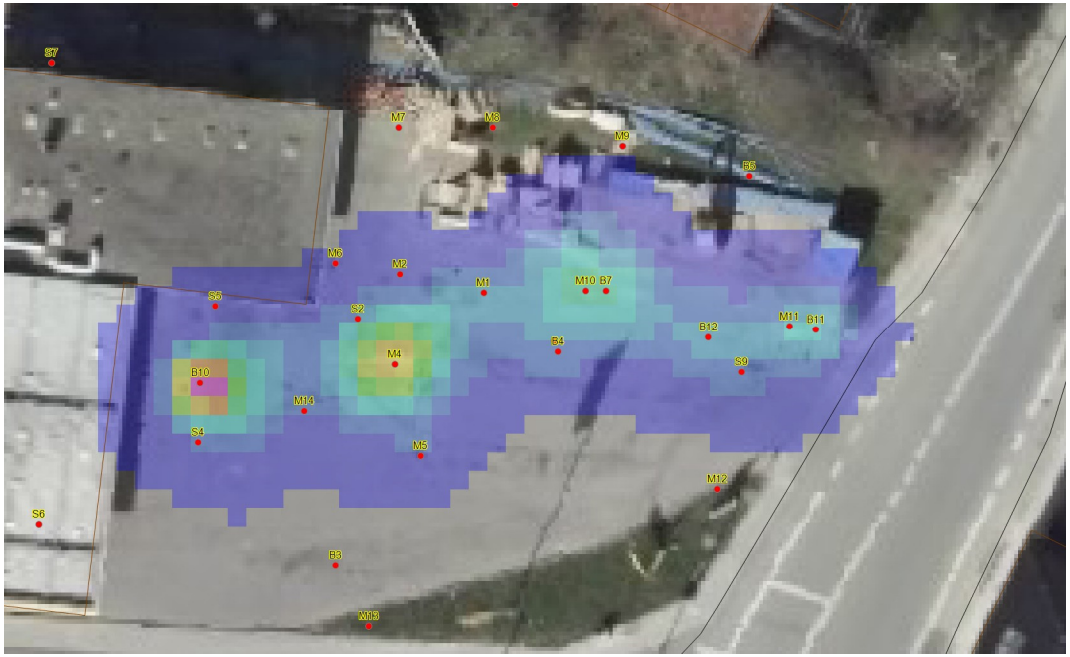
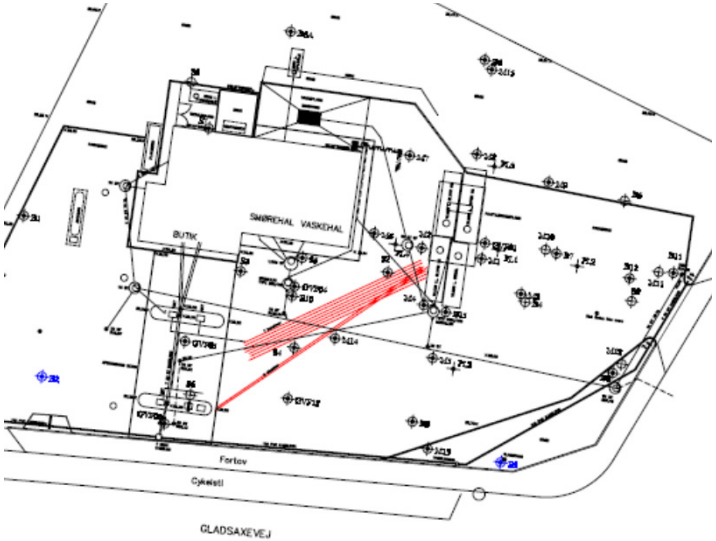


Site Example - Modelling of available data prior RDC



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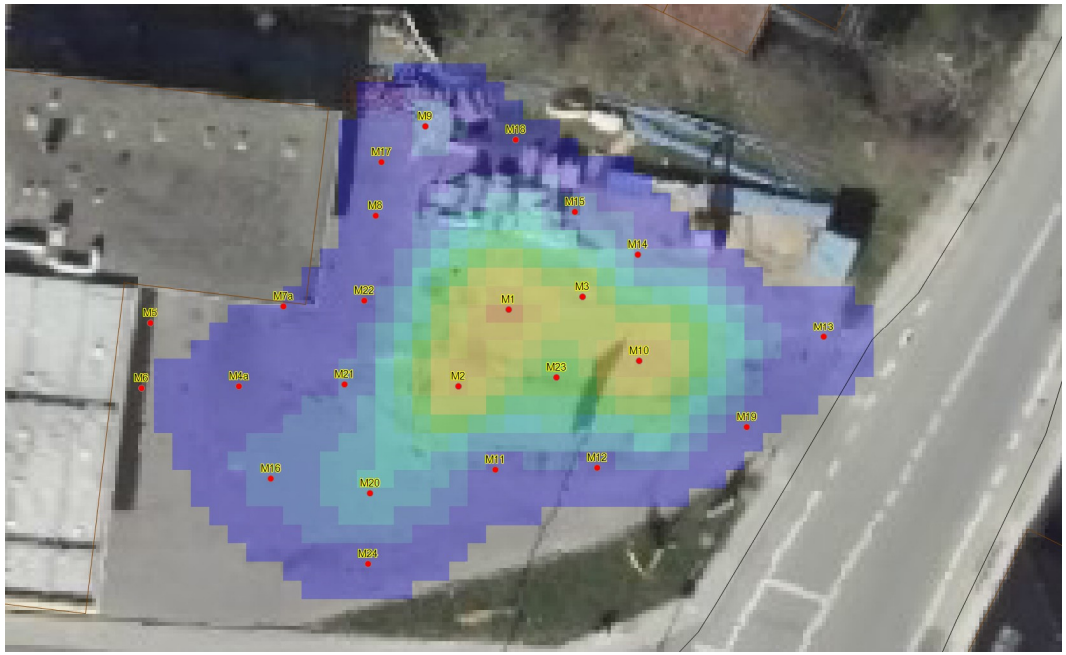
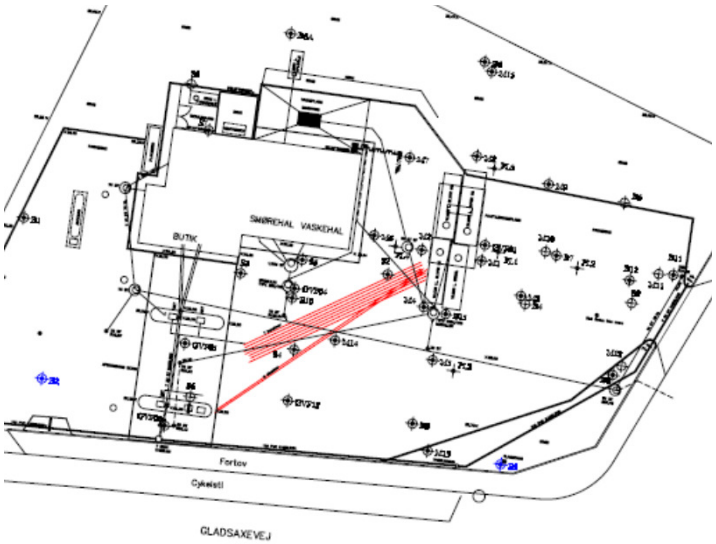


Modelling of new data from RDC



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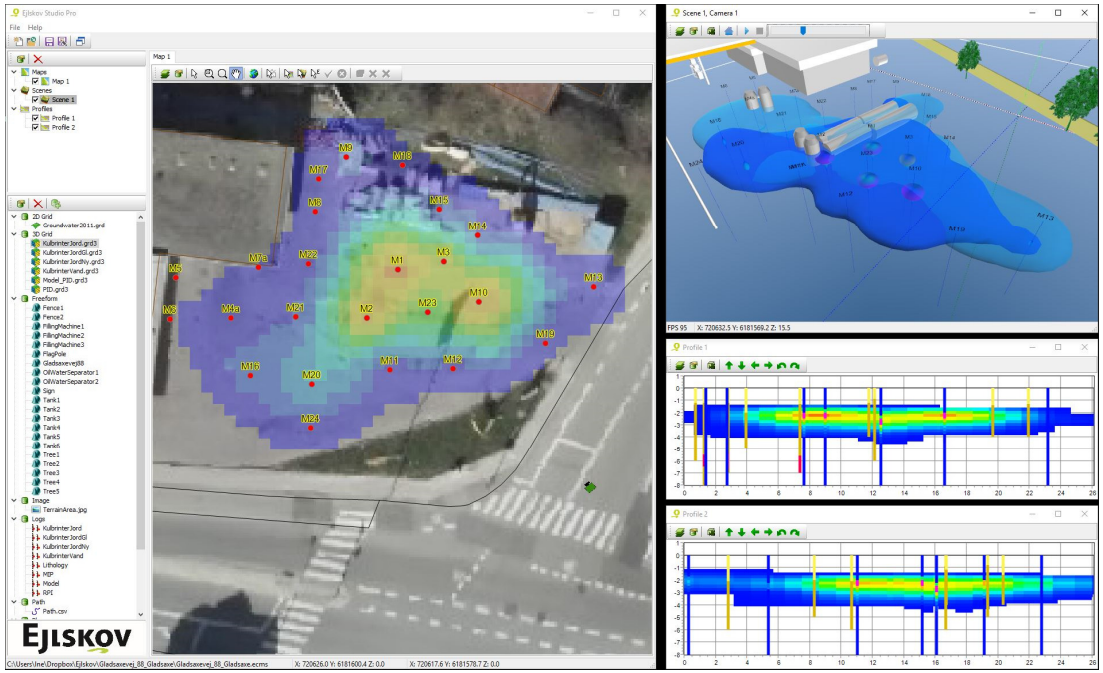

Final Model including 3D illustration and cross sc Modelling of available data prior RDC



RDC

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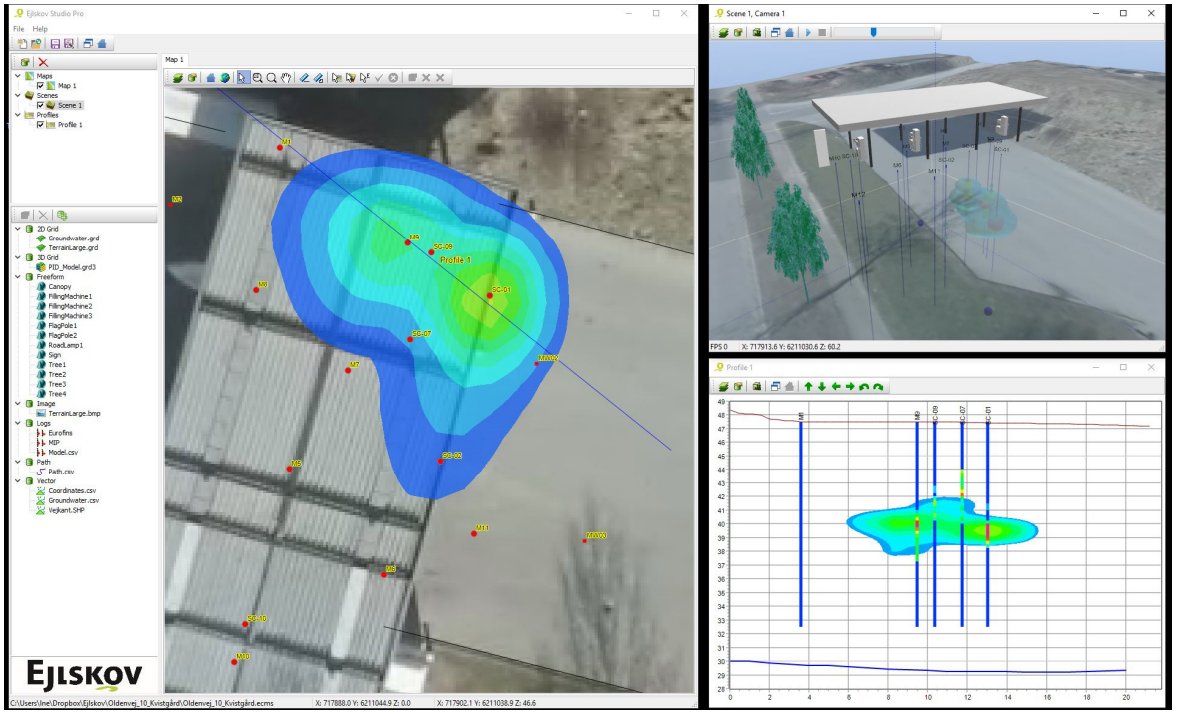
2D/3D Modeling and data evaluation, Case Study, Kvistgaard, DK

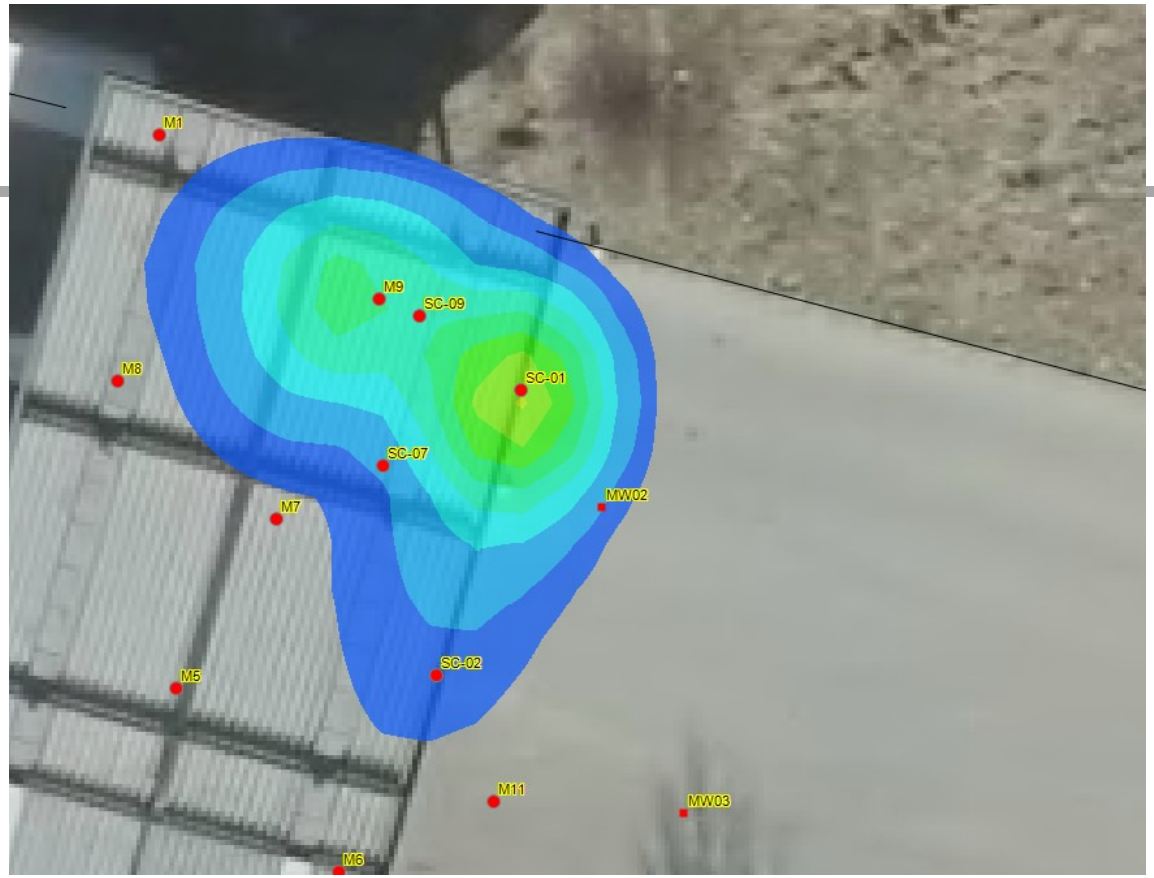
Ejlskov Studio Pro

3D Mass distribution and Remedial Design Model

Getting the contaminant mass distribution right.

- Remedial Design Characterisation (RDC)
  - For design of remediation
  - Focused on “hot” areas
    - Source Zone
    - Plume Zone
- Development of 3D contamination mass model
- Decide on the goal
  - Risk removal (still in the books)
  - Liability removal (out of the books)
  - To evaluate remedial methods





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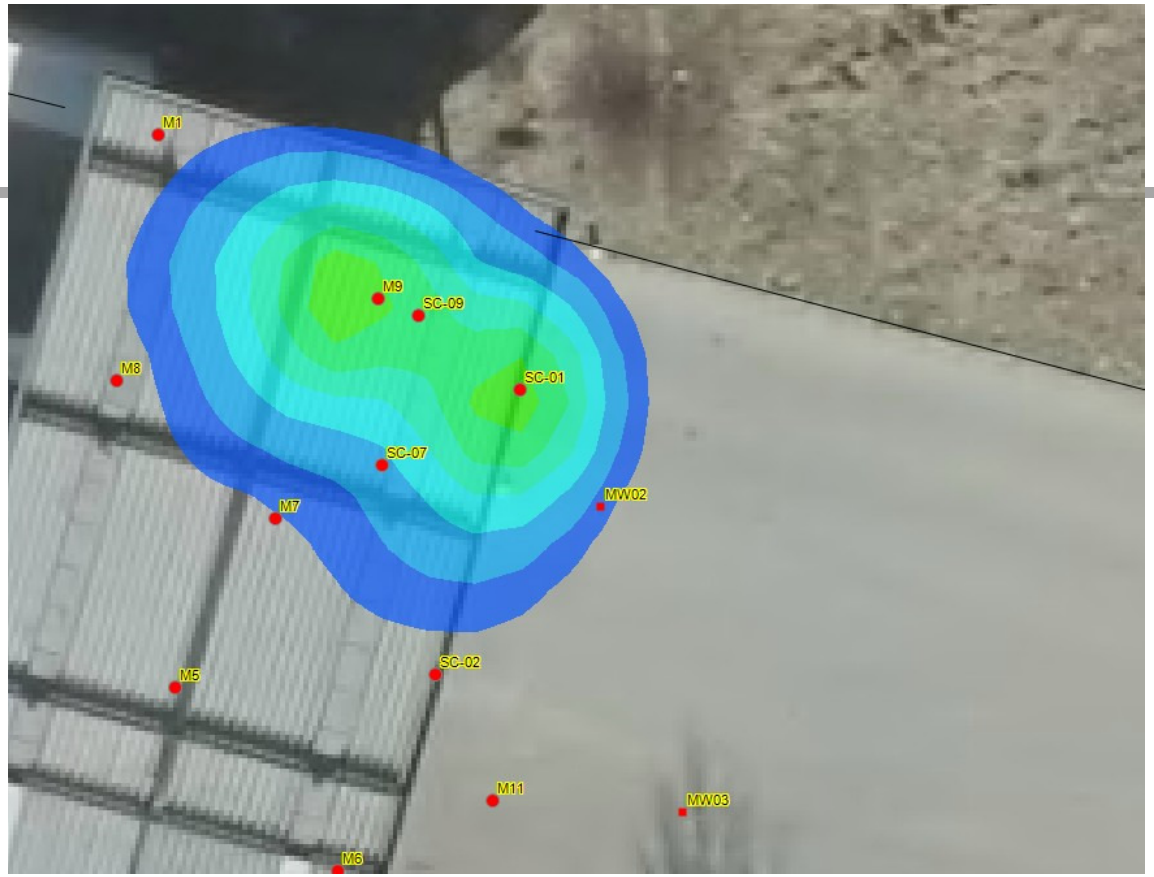
MIP 2D Model 9,5 m bgl profile



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MIP 2D Model 7,5 m bgl profile

MIP 3D Model View

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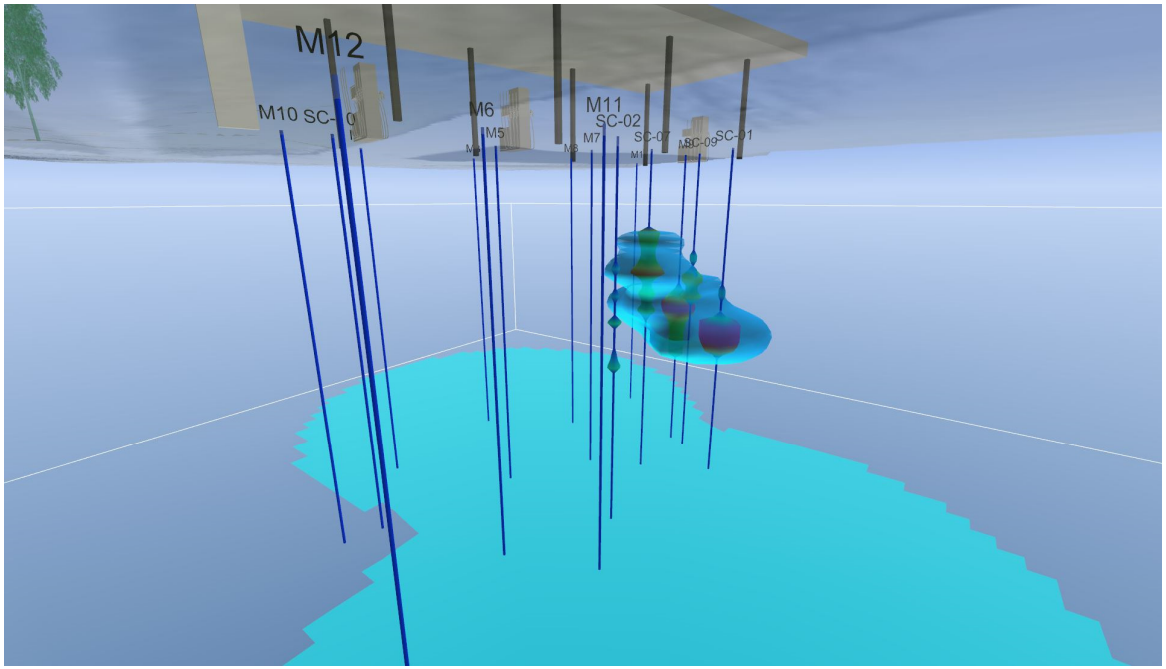
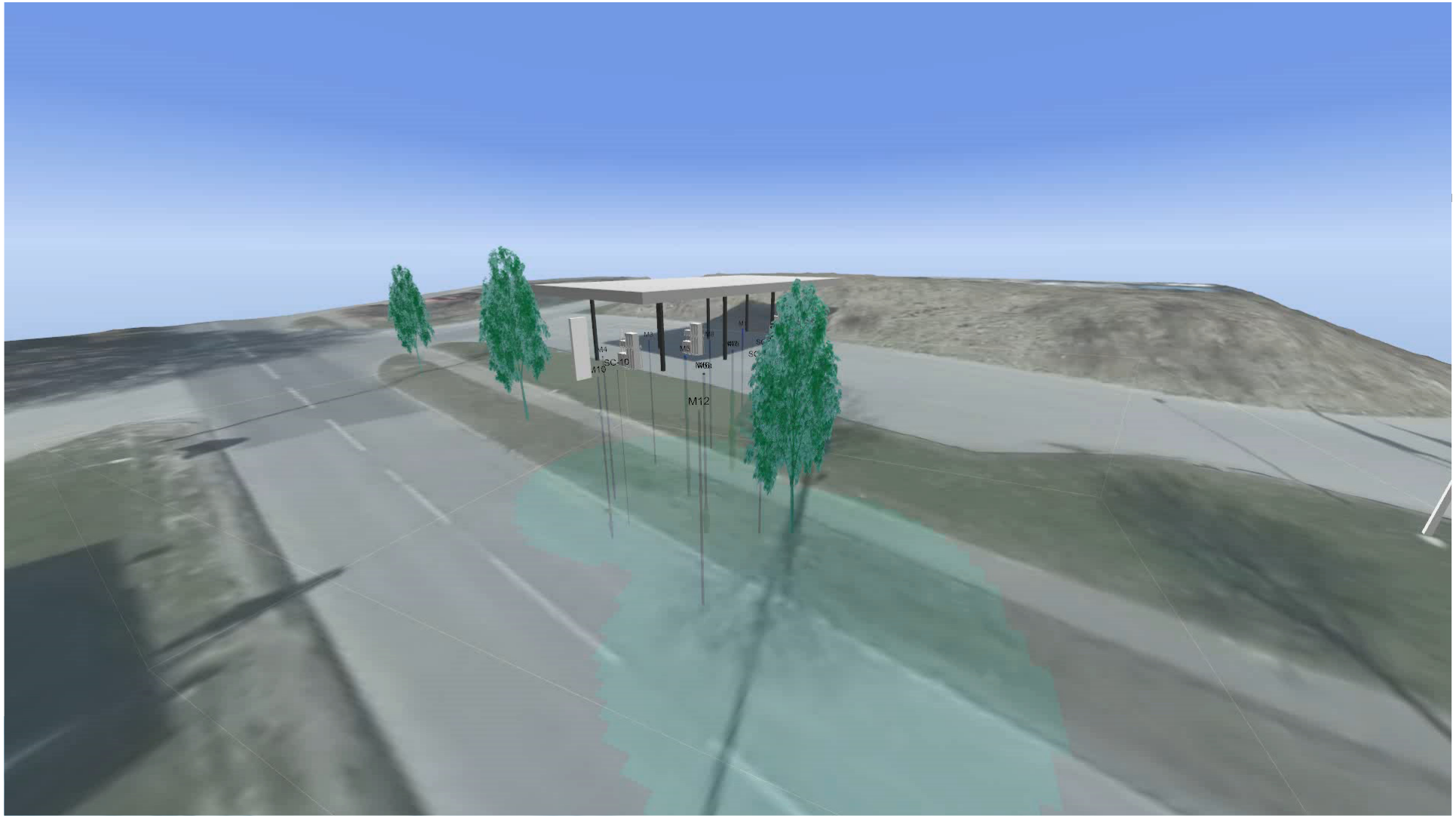


MIP 3D VIEW
Hydrocarbon MIP Probe
Delineation and
confirmatory soil sampling


M12

Importance of High Frequency Data

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Soil Criteria Class	Sample ID	Prøvedybde	Dry Matter	C6H6-C10	C10-C15	C15-C20	C20-C35	Sum (C10-C20)	Sum (C6H6-C35)
		m bgl	%	mg/kg ts.	mg/kg ts.	mg/kg ts.	mg/kg ts.	mg/kg ts.	mg/kg ts.
Klasse 4	MIP 07 SC	3,75	85	210	4900	5600	3300	10000	14000
Klasse 4	MIP 07 SC	4,0	85	280	4000	4400	2200	8400	11000
Klasse 4	MIP 07 SC	4,25	92	120	2400	2600	1400	5000	6500
Klasse 4	MIP 07 SC	4,5	92	160	3200	3500	2100	6700	9000
Klasse 4	MIP 07 SC	4,75	92	130	2600	2900	1500	5400	7000
Klasse 4	MIP 07 SC	5,0	92	200	3200	4600	2000	7800	10000
Klasse 4	MIP 07 SC	5,25	96	650	7300	8000	4200	15000	20000
Klasse 4	MIP 07 SC	5,5	96	110	1400	1400	810	2800	3500
Klasse 4	MIP 07 SC	5,75	96	9,4	480	260	110	740	860
Klasse 4	MIP 07 SC	6,0	96	14	500	140	57	630	700
Klasse 4	MIP 07 SC	6,25	95	590	11000	1100	370	12000	13000
Klasse 4	MIP 07 SC	6,5	95	290	4700	240	100	4900	5300
Klasse 3	MIP 07 SC	6,75	95	< 2	79	7,0	< 20	86	86
Klasse 4	MIP 07 SC	7,0	95	510	8200	1300	580	9500	11000
Klasse 4	MIP 07 SC	7,25	94	62	1400	250	110	1700	1800
Klasse 0	MIP 07 SC	7,5	94	< 2	< 5	< 5	< 20	#	#
Klasse 0	MIP 07 SC	7,75	94	< 2	< 5	< 5	< 20	#	#
Klasse 0	MIP 07 SC	8	94	< 2	< 5	< 5	< 20	#	#
Klasse 0	MIP 07 SC	8,25	90	< 2	< 5	< 5	< 20	#	#
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Klasse 0	MIP 07 SC	8,75	90	< 2	< 5	< 5	< 20	#	#
Klasse 0	MIP 07 SC	9,0	90	< 2	< 5	< 5	< 20	#	#
Klasse 0	MIP 07 SC	9,25	98	< 2	< 5	< 5	< 20	#	#
Klasse 0	MIP 07 SC	9,5	98	< 2	< 5	< 5	< 20	#	#
Klasse 0	MIP 07 SC	9,75	98	< 2	< 5	< 5	< 20	#	#
Klasse 4	MIP 09 SC	5,0	92	12	1100	2500	1600	3600	5200
Klasse 3	MIP 09 SC	5,25	95	< 2	6,5	18	< 20	24	24
Klasse 3	MIP 09 SC	5,5	95	< 2	7,3	16	< 20	23	23
Klasse 4	MIP 09 SC	5,75	97	61	3700	5700	3700	9400	13000
Klasse 4	MIP 09 SC	6,0	97	65	3500	5100	3300	8600	12000
Klasse 3	MIP 09 SC	6,25	96	< 2	46	41	< 20	88	88
Klasse 4	MIP 09 SC	6,5	96	100	2500	2000	860	4500	5400
Klasse 4	MIP 09 SC	6,75	95	260	4800	5100	3000	9900	13000
Klasse 4	MIP 09 SC	7,0	97	8,5	420	440	190	860	1100
Klasse 0	MIP 09 SC	7,25	95	< 2	< 5	< 5	< 20	#	#
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Klasse 0	MIP 09 SC	8,25	90	< 2	< 5	< 5	< 20	#	#
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Klasse 0	MIP 09 SC	9,5	91	< 2	< 5	< 5	< 20	#	#

Ejlskov A/S , 16064, Kvistgård CRT

Soil Criteria Class	Sample ID	Prøvedybde	Dry Matter	C6H6-C10	C10-C15	C15-C20	C20-C35	Sum (C10-C20)	Sum (C6H6-C35)
		m bgl	%	mg/kg ts.	mg/kg ts.	mg/kg ts.	mg/kg ts.	mg/kg ts.	mg/kg ts.
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Klasse 0	MIP 10 SC	5,0	96	< 2	< 5	< 5	< 20	#	#
Klasse 0	MIP 10 SC	5,5	96	< 2	< 5	< 5	< 20	#	#
Klasse 0	MIP 10 SC	6,0	98	< 2	< 5	< 5	< 20	#	#
Klasse 0	MIP 10 SC	6,25	98	< 2	< 5	< 5	< 20	#	#
Klasse 0	MIP 10 SC	6,5	98	< 2	< 5	< 5	< 20	#	#
Klasse 0	MIP 10 SC	6,75	98	< 2	< 5	< 5	< 20	#	#
Klasse 0	MIP 10 SC	7,0	93	< 2	< 5	< 5	< 20	#	#
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Klasse 0	MIP 10 SC	7,5	93	< 2	< 5	< 5	< 20	#	#
Klasse 0	MIP 10 SC	7,75	93	< 2	< 5	< 5	< 20	#	#
Klasse 0	MIP 10 SC	8,0	96	< 2	< 5	< 5	< 20	#	#
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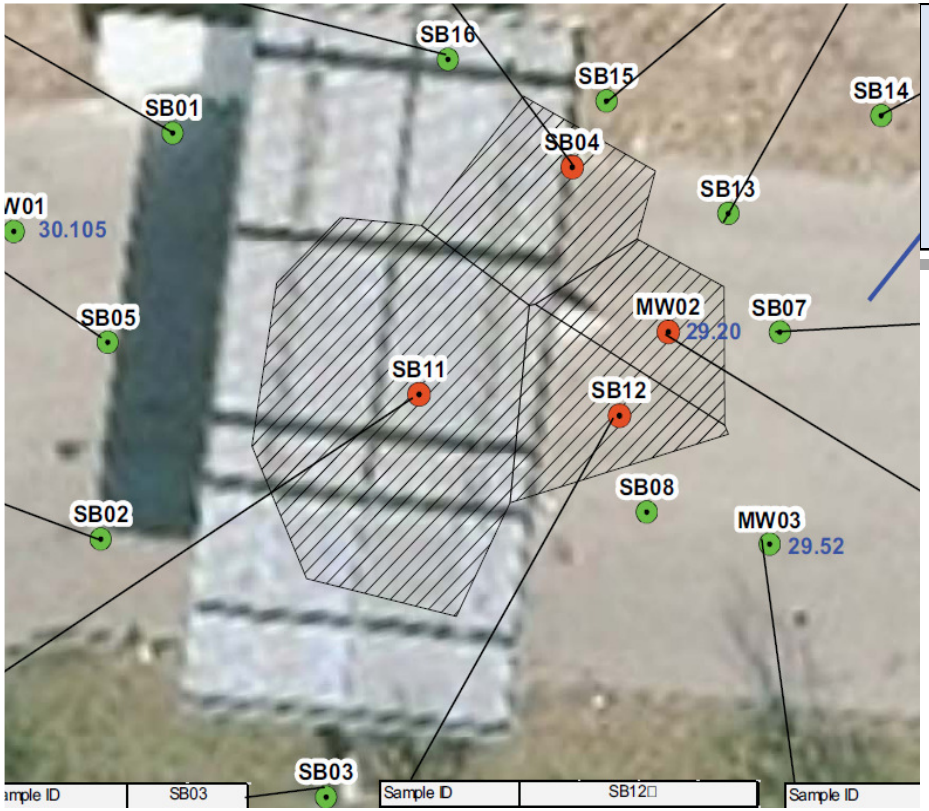
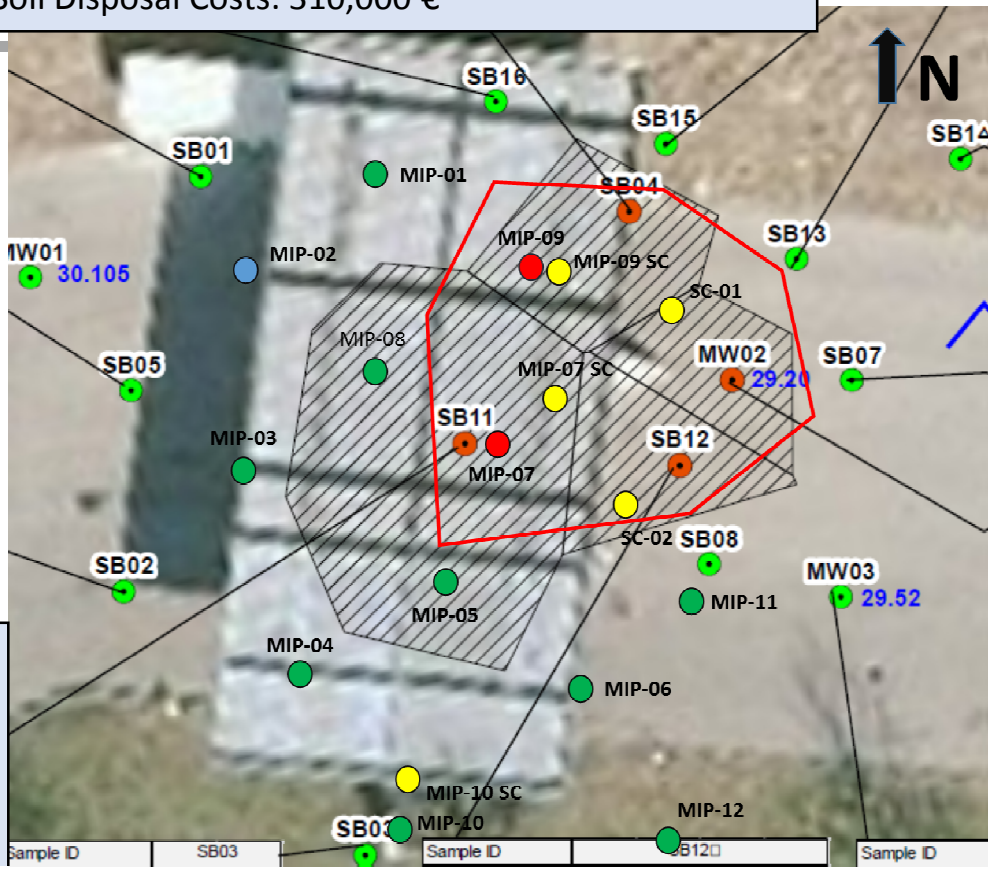
Klasse 0	MIP 10 SC	9,25	90	< 2	< 5	< 5	< 20	#	#
Klasse 0	MIP 10 SC	9,5	90	< 2	< 5	< 5	< 20	#	#
Klasse 0	MIP 10 SC	9,75	90	< 2	< 5	< 5	< 20	#	#
Klasse 0	MIP 10 SC	10,0	91	< 2	< 5	< 5	< 20	#	#
Klasse 0	MIP 10 SC	10,25	91	< 2	< 5	< 5	< 20	#	#
Klasse 0	MIP 10 SC	10,5	90	< 2	< 5	< 5	< 20	#	#
Klasse 0	MIP 10 SC	10,75	90	< 2	< 5	< 5	< 20	#	#
Klasse 0	MIP 10 SC	11,0	90	< 2	< 5	< 5	< 20	#	#
Klasse 0	SC-01	4,0	74	< 2	< 5	< 5	< 20	#	#
Klasse 4	SC-01	4,5	74	< 2	9,0	5,2	140	14	150
Klasse 4	SC-01	6,0	87	29	760	880	410	1600	2100
Klasse 2	SC-01	6,5	87	< 2	28	45	23	73	96
Klasse 4	SC-01	7,0	94	3,6	140	170	82	310	400
Klasse 4	SC-01	7,5	92	430	8200	8600	4000	17000	21000
Klasse 4	SC-01	7,75	92	340	5200	5500	2400	11000	13000
Klasse 4	SC-01	8,0	90	390	8500	9300	4500	18000	23000
Klasse 4	SC-01	8,25	90	360	8700	11000	5000	20000	25000
Klasse 4	SC-01	8,5	90	61	1600	2300	1000	3900	5000
Klasse 4	SC-01	8,75	88	92	5700	7800	3600	13000	17000
Klasse 4	SC-01	9,0	88	< 2	8,5	14	< 20	22	22
Klasse 3	SC-01	9,25	88	< 2	7,2	11	< 20	19	19
Klasse 0	SC-01	9,5	91	< 2	< 5	< 5	< 20	#	#
Klasse 0	SC-01	9,75	91	< 2	< 5	< 5	< 20	#	#
Klasse 0	SC-02	4,0	64	< 4	< 10	< 10	49	#	49
Klasse 4	SC-02	4,5	83	< 2	170	740	650	910	1600
Klasse 4	SC-02	5,5	83	70	1200	750	700	2000	2700
Klasse 4	SC-02	6,5	91	130	3200	770	660	4000	4800
Klasse 4	SC-02	7,5	96	7,8	270	34	30	310	350
Klasse 0	SC-02	7,75	96	< 2	< 5	< 5	< 20	#	#
Klasse 4	SC-02	8,0	96	89	1300	110	39	1400	1500
Klasse 4	SC-02	8,25	97	230	3900	1800	730	5700	6600
Klasse 0	SC-02	8,5	97	< 2	36	16	< 20	52	52
Klasse 0	SC-02	8,75	97	< 2	< 5	< 5	< 20	#	#
Klasse 0	SC-02	9,0	97	< 2	< 5	< 5	< 20	#	#
Klasse 0	SC-02	9,25	97	< 2	< 5	< 5	< 20	#	#
Klasse 0	SC-02	9,5	94	< 2	< 5	< 5	< 20	#	#
Klasse 0	SC-02	9,75	94	< 2	< 5	< 5	< 20	#	#



PRE RDC
Areal extent: ~ 200 sqm
Contamination Depths: 8 m bgl to 9 m bgl
Estimated Soil Contaminant Volume:~ 1,700 m3
Soil Disposal Costs: 310,000 €



POST RDC
Areal extent: ~ 120 sqm
Contamination Depths: 7 m bgl to 9 m bgl
Estimated Soil Contaminant Volume:~ 950 m3
Soil Disposal Costs: 175,000 €

Coffee Break


Thanks!
EJLSKOV
Cleaning up the earth